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HEXADECYL ALCOHOL AS A SPINDLE MOISTENING AGENT FOR MECHANICAL COTTON PICKERS[1/]

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Water is generally used to moisten the spindles of mechanical cotton pickers. A moistener is applied to keep the spindle barbs free of juices and plant parts and to help pull the cotton from the boll. If allowed to accumulate on the spindle, foreign material interferes with the operating efficiency of the picker.

The main disadvantage of using water is that it increases the moisture in mechanically harvested cotton by 1 or 2 percent. The increased use of mechanical harvesters in recent years has increased the time lapse between harvesting and ginning, and the increased moisture in mechanically harvested cotton adds to the degree of deterioration while it is in trailer storage. A better moistening agent is needed to help overcome these problems.

Several methods of eliminating or reducing the problem of excess moisture in spindle-harvested seed cotton have been tried since 1945 at Stoneville, Miss.[4/] In recent years, studies have also been conducted in California, Texas, Arizona, and Oklahoma. Many studies involved the use of anhydrous agents in lieu of water as a spindle moistener. The use of anhydrous agents has the following advantages: (a) The low freezing point of such agents eliminates the need for daily drainage of the picker supply tank during cold weather; (b) the small quantity used makes it necessary to fill supply tanks only once or twice a season compared with daily filling when water is used; and (c) the inside of the picker is noticeably cleaner, and the time required to keep it clean throughout a day's operation is greatly reduced.

1/ The research was a cooperative investigation between the Agricultural Engineering Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the Mississippi Agricultural Experiment Station, Delta Branch, Stoneville, Miss., and is a contribution to Regional Cotton Mechanization Project, S-2.

2/ Agricultural Engineering Research Division, Agricultural Research Service, U.S. Department of Agriculture.

3/ Market Quality Research Division, Agricultural Research Service, U.S. Department of Agriculture.

4/ Parker, R. E., Wooten, O. B., Williamson, E. B., and Colwick, R. F. effects of experimental spindle moistening agents on quality of mechanically-harvested cotton. Proc., SE Sec., Amer. Soc. Agr. Engrs., Jacksonville, Fla. Feb. 6, 1962.

These advantages are contingent upon the anhydrous agent having no harmful effect on cotton quality. Past studies have shown that some anhydrous agents are harmful.[5/] Textile mills are particularly concerned about contamination of lint by mechanical pickers, whether it is caused by lubricants or by spindle moistening agents. Therefore, widespread use of a harmful moistening agent could damage cotton and affect a large part of the cotton industry.

A promising anhydrous spindle moistening agent is Enjay Cotton Spray--hexadecyl alcohol.[6/7/] It has been studied extensively at several locations in the Cotton Belt for 4 years. This report covers the 4-year study conducted at Stoneville, Miss., beginning in 1959.

PRELIMINARY TESTS

In 1959

Seed cotton was mechanically harvested using water, hexadecyl alcohol, and hexadecyl alcohol plus an emulsifier as spindle moistening agents. All lots received the same ginning treatment and were spun at the Textile Research Laboratory at Lubbock, Texas.

The most important results are shown in table 1. Hexadecyl alcohol alone appeared to be at least as effective as water. However, cotton that had been picked when spindles were moistened with emulsified hexadecyl alcohol at the rate of 0.245 of a gallon per bale had excessive ends down in spinning. Because of this, further studies with emulsified hexacedyl alcohol were discontinued. Additional studies with variable rates of straight hexadecyl alcohol were performed later.

In 1960

Since the relatively low rate of hexadecyl alcohol (0.245 of a gallon per bale) applied in 1959 had no apparent harmful effects on cotton quality, an excessively high rate was applied in 1960 to see if hexadecyl alcohol applied at any rate would affect spinning qualities of the cotton. Enjay Cotton Spray

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5/ Parker, R. E., Williamson, E. B., Wooten, O. B., and Colwick, R. F. oils used as mechanical picker spindle moisteners may affect cotton's quality. Miss. Agr. Expt. Sta. Inform. Sheet 774. August 1962.

6/ The authors wish to express their appreciation to Theodore Lewis, chemist, Enjay Chemical Company, for supplying all hexadecyl alcohol used in this study.

7/ Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

Table 1. Effects of spindle moistening agents on picker efficiency, spinning performance, and fiber properties, Stoneville, Miss., 1959

Test item	Water	Hexadecyl alcohol[1/]	Hexadecyl alcohol plus emulsifier[1/]
Picker efficiency[2/]----------pct.	86.1	87.4	86.9
Spinning performance:			
Ends down per 1,000 spindle hours[3/]	44.7	44.8	114.8
Break factor----------units	1683	1736	1487
Yarn appearance----------index	90	95	80
Nonlint----------pct.	2.0	2.2	1.8
Total picker and card waste----------pct.	7.5	7.4	8.3
Neps----------per 100 sq. ins.	18.1	16.8	20.7
Fiber properties:			
Upper half mean length----------in.	1.08	1.11	1.08
Mean----------in.	.86	.88	.87
Uniformity----------ratio	79	80	81
Pressley strength----------1,000 p.s.i.	77.3	75.7	77.4
Micronaire----------reading	4.25	4.16	4.08
Maturity----------index	77	74	75

1/ Applied at the rate of 0.245 of a gallon per bale.
2/ No significant difference between treatments.
3/ The EDMSH was averaged from the following spindle hours of spinning: Water--15,000; alcohol--25,000; alcohol plus emulsifier--5,000.

was applied to a half-bale lot at the rate of 0.85 of a gallon per bale. Another half-bale lot was harvested from the same field as a check. Both lots were processed and tested at Lubbock, Tex. Results show that the hexadecyl alcohol possibly had a slightly adverse effect on fiber strength, ends down per thousand spindle hours of spinning, yarn break factor, neps, and yarn grade (table 2).

Table 2. Effects of Enjay Cotton Spray on seed cotton harvesting and fiber properties, Stoneville, Miss., 1960

Test item	Enjay Cotton Spray	Water
Application per bale---------gallons	0.85	5.6
Picker efficiency-----------percent	89.4	83.3
Seed cotton trash content----percent	7.24	8.70
Lint grade--------------designation	SLM-	SLM
Lint grade----------------------index	92.0	92.8
Upper half mean length--------inches	1.11	1.13
Strength----------------1,000 p.s.i.	73.5	78.2
Micronaire (fineness)--------reading	4.2	4.4
Card waste------------------percent	7.74	6.05
Ends down per 1,000 spindle hours---	73.2	67.5
Break factor-------------------units	1,390	1,759
Neps----------------per 100 sq. ins.	22.3	13.1
Yarn color:		
Gray (unbleached)-------------index	94	94
Bleached----------------------index	111	112
Bleached and dyed-------------index	100	99
Yarn appearance---------------grade	D	C

In 1961

It was proposed that half-bale lots of cotton would be harvested by use of each of the following rates of hexadecyl alcohol per bale as a spindle moistener: (a) 0.25 of a gallon, (b) 0.50 of a gallon, and (c) 0.75 of a gallon.

Pickers were adjusted to deliver approximately these rates per bale by allowing the spindles to rotate, adjusting the moistener control valves, and estimating the rate of alcohol flow per bale at each valve setting. The rates of hexadecyl alcohol actually consumed in the field per bale were 0.35 of a gallon, 0.48 of a gallon, and 0.82 of a gallon. A half-bale check (control) was harvested on the same day using water at the rate of 1.9 gallons per bale for the spindle moistener. All lots were ginned immediately after harvesting and shipped to Lubbock, Tex., for processing.

Table 3 shows the effect of applying three rates of alcohol on various cotton qualities. Among the qualities that could be statistically analyzed, leaf grade and spinning performance were adversely affected by the high rate of alcohol, but the medium and high rates of application tended to benefit fiber upper half mean length. In no instance was there any significant difference between the check (control), on which water had been used, and the low rate of alcohol. Although no analysis could be made, it appeared that the high rate of alcohol caused an increase in nep count.

Field performance of machines using Enjay Cotton Spray during the 3 years of preliminary testing was generally satisfactory for all of the rates used. However, the effects of the several rates of alcohol on some of the cotton's properties, especially nep content, fiber strength, and spinning performance, were inconclusive. It was concluded, however, that alcohol applied at a rate of more than 0.80 of a gallon per bale adversely affected nep content and spinning performance of cotton in 1960 and 1961.

Table 3. Effects on cotton qualities of water and variable rates of hexadecyl alcohol applied to moisten spindles of mechanical pickers--crop of 1961

[Values underscored by the same line are not significantly different at the 0.01 percent level according to Duncan's multiple range test]

Test item	Water 1.9 gal. per bale 1/	Hexadecyl alcohol per bale		
		0.35 gal.	0.48 gal.	0.82 gal.
Grade elements:				
Leaf by classer----------index	94.0	91.8	89.5	85.0
Color by classer----------index	94.0	94.0	94.0	94.0
Color by colorimeter---------index	89.0	89.0	89.0	89.0
Fibrograph data:				
Upper half mean length--------in.	1.06	1.07	1.10	1.09
Mean length----------in.	.89	.88	.90	.89
Fiber strength-------grams per tex	21.2	21.4	21.8	21.8
Fiber fineness, micronaire reading	4.3	4.3	4.2	4.1
Spinning data:				
Ends down per thousand spindle hrs	61.7	57.5	79.4	94.6
Yarn color----------index	105	109	104	104
Large neps per 100 sq. in. of card web----------	6.2	4.7	7.3	17.8
All neps per 100 sq. in. of card web----------	32.3	25.1	32.4	49.7

1/ Control lot was picked with water only.

COMPREHENSIVE TESTS OF 1962

The comprehensive tests of 1962 were designed to yield more reliable information on the effects of applying hexadecyl alcohol at rates between 0.20 and 0.50 of a gallon per bale.

Procedure

Twelve bales of Stoneville 7A cotton received the following treatments (4 treatments x 3 replications = 12 lots):

1. Check (control) picked with plain water.

2. Low rate of alcohol (0.20 to 0.29 of a gallon per bale).

3. Medium rate of alcohol (0.30 to 0.39 of a gallon per bale).

4. High rate of alcohol (0.40 to 0.49 of a gallon per bale).

The bales were harvested with a two-row tapered-spindle picker and ginned on October 3, 1962, using the following moderate gin cleaning machinery arrangement: Tower drier at 200° F., 6-cylinder cleaner, bur machine with stick remover attachment, 7-cylinder cleaner, extractor-feeder, and double lint cleaners.

The actual rate of alcohol applied was based on a bale weight of 500 pounds of lint and was calculated after each treated lot had been picked, ginned, and weighed (less ties and bagging). It was apparent that the rate of alcohol used to moisten spindles could not be estimated to the nearest tenth of a gallon per bale before harvesting because the yield of seed cotton per acre varied too widely. Therefore, the nine lots picked with alcohol as the moistening agent were regrouped into three classes, based on the actual application of alcohol per bale, which was calculated after each bale had been ginned and weighed. Fortunately, there were three replications for each treatment. Alcohol applied to spindle for each treatment and replication was as follows in gallons per bale:

1. Low rate--0.20, 0.26, 0.26.

2. Medium rate--0.31, 0.36, 0.36.

3. High rate--0.40, 0.45, 0.49.

The twelve bales of lint, each weighing approximately 300 pounds were shipped to the pilot spinning plant at Clemson, S. C., where they were stored for approximately 1 year. The bagging and ties were then removed 24 hours before the cotton was processed through the opening and picking equipment. This allowed the fiber to "bloom" and condition before processing.

All lots were processed separately from opening through spinning, using the following organization:

Opening and picking	14-ounce lap
Carding (9-1/2 lb./hr.)	50-grain sliver
Two-process drawing:	
Breaker (8 ends up)	53-grain sliver
Finisher (8 ends up)	55-grain sliver
Roving	1.10 hand (1.30 T.M.)
Spinning (single creel)	40s yarn, 4.09 T.M., 10,000 r.p.m. spindle speed

A spinning test consisted of spinning a full doff of 40s yarn on 4 spinning frames. A full doff required 10-1/4 hours of continuous frame operation and produced a test of 10,332 spindle hours. Ends down were pieced-up and recorded on 15-minute cycles. Yarn size, skein strength, single-strand strength, and Uster imperfection determinations were made on all yarns.

All fiber tests, spinning tests, and yarn-evaluation tests were performed under controlled atmospheric conditions. The Suter-Webb array, Fibrograph, "0" and 1/8-inch gage Pressley strength, and Micronaire tests were made on samples taken at intervals throughout each bale.

Results

Test results from samples collected at the gin are shown in table 4. There were no differences in the classer's grade. All samples classed Middling, and most all classed 1-1/32 inches in staple length.

All lots were fairly uniform in content of moisture and foreign matter before they were ginned. All lots were even more alike in these categories after they were ginned.

The average of three replications and a summary of the means of major fiber properties and spinning tests are shown in table 5. Full details of test results and statistical analyses are shown in appendix table 6 through 9.

Table 4. Effects on cotton qualities of water and variable rates of hexadecyl alcohol applied to moisten spindles of mechanical picker tests of 1962

[Values are averages of 9 samples, 3 for each of 3 replications]

Test item	Water only (control lot)	Hexadecyl alcohol-gallons per bale		
		0.20-0.29	0.30-0.39	0.40-0.49
Classification data:				
Grade----------index 1/	100.0	100.0	100.0	100.0
Staple length----------32nd in.	33.2	33.2	33.2	33.0
Moisture content:				
Wagon sample----------pct.	8.4	9.6	8.4	8.4
Seed sample----------pct.	9.1	9.2	9.5	8.4
Lint sample----------pct.	3.8	4.0	3.6	3.7
Foreign matter in seed cotton:				
Wagon sample:				
Hulls----------pct.	2.3	2.5	2.1	3.1
Sticks and stems----------pct.	.3	.5	.5	.6
Grass----------pct.	.2	.2	.2	.1
Large leaf----------pct.	.9	.9	.8	1.0
Small leaf----------pct.	1.1	1.1	.9	1.1
Pin trash----------pct.	1.1	1.2	1.0	1.2
Total foreign matter--------pct.	5.9	6.4	5.5	7.1
Feeder sample:				
Hulls----------pct.	.5	.5	.3	.3
Sticks and stems----------pct.	.1	.1	.1	.3
Grass----------pct.	.1	.1	0	0
Large leaf----------pct.	.3	.2	.2	.3
Small leaf----------pct.	.6	.7	.5	.6
Pin trash----------pct.	.3	.3	.3	.3
Total foreign matter--------pct.	1.9	1.9	1.4	1.8
Foreign matter removed by seed cotton cleaning----------pct.	67.8	70.3	74.5	74.6
Foreign matter in lint-------pct.	1.86	1.82	1.72	1.76

1/ 100 — Middling, etc.

Table 5. Fiber length and strength, picker and card waste, yarn strength, and ends down as effected by hexadecyl alcohol used as a spindle moistener, tests of 1962

Item	Water only (control lot)	Alcohol used on picker spindles-gallons per bale			
		0.20 to 0.29 (low rate)	0.30 to 0.39 (medium rate)	0.40 to 0.49 (high rate)	Statistical significance 1/
Suter-Webb array:					
Upper quartile length---inches	1.15	1.15	1.14	1.15	NS
Mean length---inches	.92	.92	.92	.92	NS
Coefficient of variation---percent	34	33	33	34	NS
Pressley strength:					
"0" gage---1,000 p.s.i.	83	82	80	82	NS
Total picker and card waste---percent	4.4	4.5	4.4	4.5	NS
Yarn strength:					
Break factor---units	1,734	1,701	1,692	1,705	NS
Single strand strength---grams	173.5	163.7	162.7	167.2	NS
Ends down per 1,000 spindle hours-number	71	69	62	61	**

1/ NS means not significant at 95-percent level; ** means significant at 99-percent level.

Discussion

Presence of Alcohol on Cotton Fibers

The vanadium oxinate test for alcohol was used to detect any alcohol that might have remained on the cotton fibers. This test is sensitive down to 6.5 micrograms of cetyl (hexadecyl alcohol).

All alcohol determinations were negative; no alcohol was found on the cotton fibers tested.

Fiber Properties

The use of alcohol as a wetting agent on cotton picker spindles had no significant effect on fiber length and length distribution, as measured by the Suter-Webb array test, on fiber strength, and on "0" gage Pressley test (table 5).

According to the analyses of variance, the alcohol used as a wetting agent had no significant effect on any fiber properties at the 95 percent probability level, except Fibrograph uniformity ratio (appendix table 7).

Cotton harvested at the medium and high rates of application of the wetting agent produced lint that had a uniformity ratio of 79, but that harvested with water (the control) and with a low rate of application of the alcohol produced lint that had a uniformity ratio of 77. These differences are so small that they are not considered to have any pratical importance.

Processing Properties

Picker and card waste were not significantly affected by the use of hexadecyl alcohol as a wetting agent on the picker spindles (table 5). Total picker and card waste ranged from 4.4 to 4.6 percent (appendix table 8).

Hexadecyl alcohol used as a picker spindle wetting agent had no significant effect on yarn strength (table 5). The differences between the extreme break factors represent only a 1-pound difference in skein strength.

Cotton harvested by use of the medium and high application rates of alcohol as a wetting agent produced significantly lower ends down per 1,000 spindle hours (EDMSH) than did the cotton that was harvested with water (control), and with the low application rate of the alcohol wetting agent (table 5). The high application rate produced an average of 61 EDMSH, while water (control) produced 71 EDMSH.

The difference in ends down may not be real because of the lack of significant differences between treatments for most fiber properties, the negative residual alcohol determinations, and the relatively small differences in ends down obtained in the test. The standard error of the mean of three determinations of ends down is ordinarily larger than the 1.3 ends down obtained in this test.

Alcohol had no significant effect at the 95-percent probability level on any other processing properties (appendix tables 8 and 9).

CONCLUSION

The results of this 4-year study indicate that the use of hexadecyl alcohol as a wetting agent on the picker spindles had no adverse effects on fiber properties, yarn properties, or spinning performance when used at rates ranging from 0.20 to 0.50 of a gallon per bale.

There is an indication based on the 1962 data that spinning performance was improved when from 0.30 to 0.50 of a gallon of alcohol per bale was used; however, the 1961 data (based on only one sample) indicated that spinning performance was adversely affected when 0.48 of a gallon of alcohol was used. Therefore, the differences in spinning performance in 1962 probably were not real because no other significant effects on fiber properties were noted. In addition, the differences in spinning performance in 1961 were probably due to chance or to one or more uncontrolled variables.

The relatively high rates of alcohol applied to picker spindles in 1960 and 1961 (0.85 of a gallon and 0.82 of a gallon per bale, respectively) caused a considerable increase in nep count and a slight decrease in spinning performance over the control lot for both years. The use of the alcohol as a spindle moistener at these rates should be avoided at all times.

Table 6. Fiber length and length distribution (array method) as effected by hexadecyl alcohol used as a picker spindle moistener, tests of 1962

Item tested	Replication	Water only (Control treatment)	Alcohol used on picker spindles - gallons per bale			Statistical significance[1/]
			0.20 - 0.29 (Low rate)	0.30 - 0.39 (Medium rate)	0.40 - 0.49 (High rate)	
Upper quartile length (inches)	1	1.16	1.14	1.14	1.15	
	2	1.14	1.14	1.15	1.15	
	3	1.15	1.16	1.14	1.16	NS
	Average	1.15	1.15	1.14	1.15	
Mean length (inches)	1	.93	.92	.92	.92	
	2	.91	.91	.92	.92	
	3	.92	.92	.92	.92	NS
	Average	.92	.92	.92	.92	
Coefficient of variation (percent)	1	34	32	34	34	
	2	34	33	33	34	
	3	33	33	32	33	NS
	Average	34	33	33	34	
Fibers shorter than 1/2 inch (percent)	1	12.4	12.0	12.6	12.6	
	2	13.1	12.4	11.9	13.4	
	3	11.9	12.0	11.8	11.7	NS
	Average	12.5	12.1	12.1	12.6	
Fibers 1/2 inch to 1 inch	1	36.6	39.6	36.8	38.2	
	2	39.4	39.2	36.7	38.2	
	3	38.4	39.3	41.3	38.4	NS
	Average	38.1	39.4	38.3	38.3	
Fibers 1 inch and longer (percent)	1	51.2	48.4	50.6	49.0	
	2	47.6	48.5	51.4	48.3	
	3	49.6	48.8	46.9	50.0	NS
	Average	49.5	48.6	49.6	49.1	

1/ NS means not significant at 95-percent level.

Table 7. Fiber length and strength measurements as effected by hexadecyl alcohol used as a picker spindle moistener, tests of 1962

Item tested	Replication	Water only (Control treatment)	Alcohol used on picker spindles -- gallons per bale			Statistical significance[1/]
			0.20 - 0.29 (Low rate)	0.30 - 0.39 (Medium rate)	0.40 - 0.49 (High rate)	
Upper half mean (inches)	1	1.02	1.01	1.02	1.00	
	2	1.03	1.01	1.02	1.02	
	3	1.03	1.02	1.02	1.04	NS
	Average	1.03	1.01	1.02	1.02	
Mean (inches)	1	.78	.78	.80	.78	
	2	.80	.78	.80	.80	
	3	.81	.79	.80	.84	NS
	Average	.80	.78	.80	.81	
Uniformity ratio	1	76	77	78	78	
	2	77	76	78	78	
	3	79	78	80	81	*
	Average	77	77	79	79	
"0" gage (1,000 p.s.i.)	1	85	85	78	84	
	2	82	84	82	81	
	3	82	78	80	80	NS
	Average	83	82	80	82	
1/8 inch gage (grams/tex)	1	20.3	20.3	20.4	20.2	
	2	20.4	20.4	21.0	20.5	
	3	20.6	20.2	20.2	20.7	NS
	Average	20.4	20.3	20.5	20.5	
Micronaire (reading)	1	4.6	4.8	4.6	4.6	
	2	4.6	4.8	4.6	4.7	NS
	3	4.8	4.8	4.8	4.8	
	Average	4.7	4.8	4.7	4.7	

[1/] NS means not significant at 95-percent level; * means significant at 95-percent level.

Table 8. Stated cotton properties as effected by hexadecyl alcohol used as a picker spindle moistener, tests of 1962

Item tested	Replication	Water only (Control treatment)	Alcohol used on picker spindles - gallons per bale			Statistical significance 1/
			0.20 - 0.29 (Low rate)	0.30 - 0.39 (Medium rate)	0.40 - 0.49 (High rate)	
Adjusted total picker and card waste (percent)	1	4.50	4.51	4.39	4.59	
	2	4.36	4.60	4.37	4.61	
	3	4.41	4.38	4.42	4.36	NS
	Average	4.42	4.50	4.39	4.52	
Neps per 100 square inches	1	19	18	19	18	
	2	18	20	16	17	
	3	13	16	15	15	NS
	Average	17	18	17	17	
Break factor 40s yarn (units)	1	1763	1722	1669	1741	
	2	1710	1709	1735	1688	
	3	1728	1671	1673	1686	NS
	Average	1734	1701	1692	1705	
Single strand strength (grams)	1	166.4	165.6	165.0	166.8	
	2	173.8	162.4	160.2	170.4	
	3	180.4	163.0	163.0	164.4	NS
	Average	173.5	163.7	162.7	162.7	
Single strand strength coefficient of variation (percent)	1	11.0	11.9	12.3	13.1	
	2	13.1	12.0	11.4	12.0	
	3	12.5	12.6	13.2	14.2	NS
	Average	12.2	12.2	12.3	13.1	
Ends down per 1,000 spindle hours (corrected)	1	73	71	62	60	
	2	66	67	59	57	
	3	74	68	65	66	**
	Average	71	69	62	61	

1/ NS means not significant at 95-percent level; ** means significant at 99-percent level.

Table 9. Yarn properties as effected by hexadecyl alcohol used as a picker spindle moistener, tests of 1962

Item tested	Replication	Water only (Control treatment)	Alcohol used on picker spindles - gallons per bale			Statistical significance[1/]
			0.20 - 0.29 (Low rate)	0.30 - 0.39 (Medium rate)	0.40 - 0.49 (High rate)	
Neps per 1,000 yards (number)	1	1308	1362	1464	1340	
	2	1293	1248	1252	1415	
	3	1014	1328	1131	1236	NS
	Average	1205	1313	1282	1327	
Thick places per 1,000 yards (number)	1	2160	2406	2477	2308	
	2	2280	2092	2238	2445	
	3	1983	2331	2182	2249	NS
	Average	2141	2276	2299	2334	
Low places per 1,000 yards (number)	1	724	1060	1069	750	
	2	858	583	804	1045	
	3	652	923	696	956	NS
	Average	745	855	856	917	
Irregularity coefficient of variation (percent)	1	23.6	24.6	25.1	23.9	
	2	24.1	23.8	23.9	25.2	
	3	23.4	24.7	23.4	24.9	NS
	Average	23.7	24.4	24.1	24.7	
Yarn appearance (index)	1	100	100	100	100	
	2	100	100	110	100	
	3	100	100	100	100	NS
	Average	100	100	103	100	

[1/] NS means not significant at 95-percent level.

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